Airways Communication Service [1]

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THE present development of air transport is bringing out its need for adequate communication in much the same manner as the earlier development of railway operations disclosed for that industry the necessity of special communication services if speed and density of traffic were to be obtained with safety. The electric telegraph by a most fortunate coincidence was available just at the time the railways required it; and as the demand for speed became pressing the telephone was perfected. Today the railways of the country, in general, use the telegraph for administrative messages, where a written record is wanted, and use the telephone for despatching, where speed and accuracy are primary requirements.

By another fortunate coincidence, radio appears to be available just at the time it is needed for communication with aircraft in flight. Radio in the form of either telegraph or telephone has been highly developed for communication between points on the surface of the globe. For communication between aircraft and airports it is available in principle although not yet so well developed. During the war, both in this country and abroad, radio equipment of relatively crude design was installed in aircraft and proved of great utility. Since the war, radio telegraphy for aircraft has been further developed by the naval and military services, but radio telephony has received less attention, probably because of the inherent difficulties and lack of a pressing demand.

Following the remarkable success of the Air Mail and the passage of the Air Commerce Act of 1926, we are now fairly launched into an era of air transport of mails, express and passengers. National Airways, laid out and equipped by the Department of Commerce under authority of the Air Commerce Act, already compare in extent with the main trunk line mileage of the railways. Scheduled flying over these airways goes on by night as well as by day. A commercial degree of reliability and safety has been reached in so far as the airplane and its engine are concerned and, when surprises due to bad weather can be eliminated, the safety of air transport should compare favorably with that of other forms of transportation.

Although weather is beyond our control, meteorological science is able to forecast its major phenomena with a high degree of precision,

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provided data describing present and past weather conditions can be collected from a sufficient number of places. The progress of a weather disturbance can be tracked and the time of its arrival at a given point predicted. By means of a suitable communication system weather reports from observers located along and near an airway can be collected; and it should be possible, therefore, to reduce materially the weather hazard of air transport.

A full-scale meteorological experiment of this nature is now being conducted in California by the Weather Bureau with the cooperation of the Guggenheim Fund for the Promotion of Aeronautics and of the Pacific Telephone and Telegraph Company. Meteorologists at the Oakland and Los Angeles airports receive several times a day, by long distance telephone, weather data from observers at a large number of selected points in the state. After an exchange of these collected data, these meteorologists forecast flying-weather for aviators starting out over the airway between these airports. The experiment will be continued until the value of the special weather service can be estimated.

Since the communications problem of safe air transport presented features which in a number of respects were unique, it was referred by the Interdepartmental Committee on Aeronautical Meteorology to experts of the American Telephone and Telegraph Company and Bell Telephone Laboratories. What was desired was the collection of reports from a considerable number of widely distributed observers in a relatively short interval of time, say, from twenty observers in twenty minutes. Naturally, it is not commercially practicable to call the party desired, set up the connections, have him answer and give his data all in the space of one minute. However, an equivalent result has been obtained by evolving a special telephone procedure for the purpose. At the appointed time a team of long-distance telephone operators call up successively the listed observers. Each as he answers is asked to hold the line and wait his turn when the operator connects him to the airport meteorologist.

It has been found by trial that the weather data can be reported and recorded in thirty seconds. Consequently, the list of observers can be readily gone through if one minute each is allowed. To the Los Angeles and Oakland airports about forty observers are now reporting weather five times a day. These collected reports are exchanged between airports; and airplanes starting over the airway are provided with a forecast of the weather they may expect enroute and upon arrival.

On the basis of these forecasts, it is hoped that the pilots may be able to avoid bad weather by choosing an alternative route or

by selecting the terminal field where weather conditions are more propitious. Both Los Angeles and the San Francisco Bay region have several airports and there are two routes between them, one up the valley via Bakersfield, and the other the more direct line to the west. The experiment will be carried on for a full year and so cover the complete cycle of the seasons. On the basis of the demonstrated value of this service to the users of the airway, the matter of its continuance or possible extension to other airways can then be decided by the Weather Bureau. Unfortunately, however, California weather is proverbially good, and the experiment will, therefore, be concerned mainly with local fog and visibility conditions. It is possible also that interests other than aeronautical may discover advantages in a short range forecast of local weather. If so, the value of the experiment will be correspondingly increased.

Weather data are also being collected in the east from observers in New Jersey and Pennsylvania by the meteorologist at Hadley Field who employs a somewhat similar method of sequence operation of the long-distance telephone lines.

In addition to the problem of collecting weather data, there is the closely related matter of distributing local weather reports and forecasts between airports. This is "point-to-point service." It may be accomplished by a special radio-telegraph network, by commercial telegraph or by long-distance telephone, and over private or leased wires either by telephone or by telegraph. Local conditions, volume of traffic and economic considerations, in general, determine which type of service should be provided.

Besides its use for weather messages, point-to-point communication between landing fields along an airway is desirable for following the progress of an airplane with its passengers and cargo. Such a despatching service is somewhat analogous to that of a railway and is a necessity if scheduled connections with trains and other aircraft are to be met. Also, there is the necessity of accountability for mails and express; for example, on departure the landing fields ahead must be informed not only of the fact of starting but of what mail is on board. Upon landing there must be a message announcing the event. In this way the progress of a plane can be followed by the terminal airports.

Although air transport of passengers has not yet reached a large volume in this country, European experience indicates that we soon will be concerned with communication problems having to do with passengers' convenience and comfort. Train and bus connections, hotel accommodations and meals, will have to be arranged for by the traffic department of an air transport company.

Point-to-point communication facilities are also required for the general administrative business of the airway and of the air transport companies.

Along our present airways at short intervals are intermediate landing fields upon which planes may land when forced down by weather or mechanical trouble. Such landings, however, are infrequent and will presumably become increasingly rare; but when a forced landing does take place instant communication with the nearest airport is urgent on account of passengers, mail, and the air transport company itself. Telephones are now provided at these intermediate fields by the Department of Commerce and kept available for such emergency use. The same telephones can be used, of course, for the routine collection of weather data by the airport meteorologist.

On some airways communication between terminal landing fields or airports is now handled by radio telegraph and on others by long-distance telephone. Neither system is ideal for the purpose. Radio telegraph is slow and is often unreliable in times of bad static when weather messages become urgent. It also utilizes radio ether channels which are needed for communication with planes. Moreover, a telegraph operator must be constantly listening throughout the twenty-four hours even though messages come infrequently. Commercial wire telephone service on the other hand although generally fast and reliable provides no written record of the messages, nor does it economically repeat messages at such other and distant airports as may be interested. Weather conditions at Cleveland, for example, are of interest both to New York and to Chicago airports. Likewise the time of departure of the New York air mail from Chicago is of interest to all landing fields enroute.

An ideal system which is instantaneous and reliable, repeats messages at all airports, is free from interference, takes up no radio channels, and furnishes a permanent record of all messages at all airports, is the telephone-typewriter service. Telephone-typewriter systems make possible the instantaneous transmission of communications between distant offices and provide simultaneously each office and any desired intermediate stations with typewritten copies. This service has been used for a good many years by the principal press associations and is now being extended rapidly to serve the needs of our larger business organizations.

To utilize the telephone-typewriter system along an airway requires only the installation of keyboard transmitting apparatus and tape printing apparatus at terminal fields and their interconnection by a private or leased wire circuit. Then anyone familiar with a type-

writer may type a message which will appear on the tape fed automatically from the apparatus at every other connected point. The message is automatically and permanently recorded under the control of the sending station. Constant attendance or listening-in is, therefore, not required; and operators at the various receiving points are thus free to attend to telephone calls from intermediate fields, to operate radio beacons and lights, and to carry on whatever duties may be assigned to them.

Telephone-typewriter service has been initiated by the Department of Commerce at Hadley Field, at Cleveland, at Chicago and at San Francisco, where in each place the local radio stations, weather bureau offices and the airport offices are all interconnected. It is planned, at a later date, to equip experimentally some airway with complete telephone-typewriter service between airports.

When an aviator leaves an airport he should be given information of the weather along the route ahead of him and a forecast of the nature of probable changes during the time of his flight. If general weather conditions are settled, or if his flight is a short one, a forecast is entirely adequate. However, for long flights and at times of uncertain and threatening weather, it is important that the pilot be continuously advised by radio of the weather conditions he may encounter during his flight. In particular, reports of the visibility and landing conditions at the airport where he expects to land and storm warnings should be sent him. Weather and landing advice can be broadcast from each airport along the airway. Provision of radio transmitters at airports and receiving sets in the planes will make possible a simple one-way system of communication and will permit any number of planes in the air to be advised without confusion.

The Department of Commerce, in its program of Aids for Air Navigation plans to install radio-telephone transmitters at principal terminal fields to broadcast, to planes in flight, weather and landing information. In addition, there will be a radio-beacon service to assist pilots in finding the landing field.

European practice, however, has not developed a broadcasting service along this line but has evolved a two-way system in which the pilot of the airplane talks with the nearest airport. Such a system has obvious advantages where it is desired by an air transport company to instruct or control rather than merely inform its aviators. The obvious disadvantage lies in the fact that on a single radio channel the airport can converse with only a single airplane at a time. On the London-Paris airway, it is reported, the practice has recently been adopted of communicating on one channel by radio telegraph with the

large planes which carry a radio operator and on another channel by radio telephone with the smaller planes.

Two-way communication has the great and obvious merit of permitting a pilot to discuss the weather outlook with an airport meteorologist, to consider alternative landing places in view of such factors as his remaining fuel supply or the direction of wind, and to decide if necessary on a change in landing place and to be assured of arrangements there for the care of his passengers and mail. It seems reason-

FIG. 1. THE WHIPPANY RADIO LABORATORY.

able, therefore, to predict that operators of air transport fleets will require two-way communication with their planes in flight, although taxi services and private owners without ground organization along the airway may, in general, be content with a public one-way broadcasting service.

Whether one-way or two-way communication is desired for plane-to-ground use it appears that radio telephony as distinguished from telegraphy will be essential. Radio telegraphy requires on board the plane the individual attention of a special radio operator for sending and receiving. Although very large multi-engined passenger planes will certainly carry a relief pilot in flight, it is doubtful whether good

commercial pilots can be made into good telegraphers and vice versa. For long distance over-sea flights and for expeditionary purposes the radio telegraph has, without doubt, preponderating advantages of longer range with the same transmitter power and of intelligibility through a higher level of interfering signals and acoustic noise on board, aside from its convenience in communication enroute with surface vessels. For regular service on established airways, however, the telephone is undoubtedly superior.

The perfection of facilities for communicating weather and landing information to planes in flight, which will enable them to operate with safety under relatively unfavorable meteorological conditions, will greatly stimulate the demand for improved aids to navigation. It seems to be established that flying under conditions of poor visibility, when landmarks are totally obscured and beacon lights are useless, requires some form of radio goniometry if the pilot is to find his way through.

A number of systems have been proposed for this purpose. The London-Paris Airway is equipped with radio direction-finding equipment on the ground by means of which the position of planes can be determined on request. The disadvantages of this arrangement lie mainly in its relative slowness and its lack of traffic capacity. The radio beacon of the type being developed by the Bureau of Standards, giving an equi-signal zone which can be observed by the plane, is free from these objections. It is, however, subject to the disadvantage that it indicates a straightline course which cannot always coincide with the airway and is of little value if detours are required to avoid storm centers and foggy areas.

Another system, a recent development of the British Royal Air Force, employs a rotating loop transmitter at the ground station and indicates the bearing of the plane with respect to the transmitter by means of a special stop watch. This system is relatively slow but permits the pilot to navigate as he would if one or more beacon lights were visible. All of these various methods of goniometry have special advantages and disadvantages, and occupy more or less of the valuable and restricted ether space. The evolution of the system which is most satisfactory will be a matter of time and will require close co-operation on the part of all factors in the industry.

Bell Telephone Laboratories, at its radio station at Whippany, New Jersey, has erected an experimental two-way radio-telephone system and radio beacon. In connection with this apparatus it utilizes a Fairchild Cabin Monoplane with Pratt and Whitney wasp engine. The plane has been carefully bonded and shielded and is

equipped with radio field-measuring apparatus of the Laboratories' design. With this plane exact measurements can be made at various altitudes under different weather conditions of the efficiency of radio transmission from the Whippany transmitter. In addition the plane carries radio transmitting and receiving sets of experimental design.

FIG. 2. THE CABIN MONOPLANE FOR EXPERIMENT IN AIRWAYS COMMUNICATION.

It is, in fact, a flying radio laboratory in which the engineers may experiment under actual flying conditions.

Whether a radio beacon service and a radio telephone service at all the various airports over the country can be made practicable is largely a question of available ether channels. By international agreement, the frequency band 285–315 kcs. (1050–950 meters) is reserved for radio beacons, both marine and air service. For "air mobile service exclusively" there is reserved the band 315–350 kcs. (950–850 meters) in which the 900 meter wave (333 kcs.) is reserved as an air service calling wave and is not to be assigned.

Radio telephony requires a band of frequencies sufficiently wide to include the "side bands" of speech frequency. For distinct transmission of speech, neglecting certain requirements of musical quality, this might require a minimum of 6,000 cycles. In this band reserved for "air mobile service exclusively" there is room, therefore, for but

three telephone channels above and three below the calling wave, or a total of six channels. Assuming that a beacon requires a channel width of but 300 cycles, there are altogether for marine and airport use one hundred beacon channels in the band 285–315 kcs.

FIG. 3. CABIN LABORATORIES OF THE MONOPLANE.

The band reserved for beacons is already partly occupied by marine beacons, and near the coast difficulty may arise in finding clear channels for airport beacons. Although it is probable that, by a proper geographical distribution of frequencies, there may be worked out without

undue interference an adequate beacon service we can make no assumption that any extra space can be found in the beacon band for radio telephony.

A radio telephone system with a sufficiently powerful transmitter and sufficiently sensitive receiver to give reliable communication for 100 miles will give fair communication for perhaps 200 miles, and its carrier wave will interfere with reception for a much greater distance. To avoid interference due to the beating of carrier frequencies, airports within a few hundred miles of one another may be assigned to different frequency channels, but serious difficulty is at once apparent from a map of the National Airways. Within 800 miles of Chicago, for example, there are over fifty terminal fields or airports. It would seem obviously impractical to assign the available six telephone channels to cover the eastern and central United States without serious interference. By restricting power as much as possible and by other means yet to be devised, it may be found possible to assign the same wave-length to airports relatively nearer together. For the distribution of weather information only, however, the airways may well find insufficient the frequencies in the exclusive band, 315–350 kilocycles.

On certain main routes, air transport companies will eventually require two-way telephone despatching systems of their own to control plane movements. These systems will consist of radio stations situated at the various airports along the route and interconnected by suitable wire lines. The frequency channels required for such services cannot be found in the 315–350 kilocycles band which, as just indicated, is apparently inadequate for the public services of weather broadcasting from airports. Further channels in the short-wave region appear to be necessary.

In the short wave region Bell Telephone Laboratories have initiated an additional development project. In cooperation with the Boeing Air Transport Company, the Laboratories have undertaken to survey the Chicago-San Francisco Airway and to develop a system of two-way telephony between planes in flight and terminal landing fields on this route. The Boeing Company planes and landing fields will be equipped with experimental radio apparatus and a joint full-scale experiment will be conducted during the winter of 1928–29. From this work it is hoped to determine for an air transport company the requirements for a two-way radio telephone service. The investigation will furnish the basis for offering such facilities to other air transport operators.

This development of two-way radio-telephony on short waves is

entirely distinct from the government's program of Aids to Air Navigation. That service contemplates one-way radio telephony and direction finding on long waves. The government service is to be available to all flyers who equip themselves to receive it. The two-way system is for private communication and despatching service of air transport companies which wish to control their planes in flight, and to remain in constant communication with their pilots and passengers.

Also, although not yet required, it can safely be predicted that at busy airports there will soon arise a need for radio means to control precedence in the take-off and landing of airplanes. This virtually amounts to traffic control and can be accomplished by low-power two-way radio telephone. Planes wishing to land may announce themselves and remain aloft until directed by the airport manager in the control tower to land at a designated part of the field.

In all these present and future problems, it is the policy of the American Telephone and Telegraph Company and the Bell System to assist by developing ways and means for making available to commercial aviation the best possible communication service.